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ECT: Phase V (All Weather) Testing
of T-29A Aircraft.

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WADC-TR-52-68

April 1952

PHASE V (ALL WEATHER) TESTING OF T-29A AIRCRAFT

Oakley W. Baron, Major, USAF

United States Air Force
Wright Air Development Center
Wright-Patterson Air Force Base, Dayton, Ohio

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WADC-TR-52-68

April 1952

PHASE V (ALL WEATHER) TESTING OF T-29A AIRCRAFT

Oakley W. Baron, Major, USAF

All Weather Section
Flight Test Division
Project No. S207-20

United States Air Force
Wright Air Development Center
Wright-Patterson Air Force Base, Dayton, Ohio

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ON

FOREWORD

This evaluation was conducted and the report prepared by the All Weather Section, Flight Test Division, Wright Air Development Center, under authority contained in Air Materiel Command Headquarters Office Instruction No. 80-4, dated 23 May 1950. The project was initiated on 29 August 1951 as All Weather Section Project No. S207-20.

Major Oakley W. Baron, the project engineer, was in charge of the flying program at Wright-Patterson Air Force Base with technical assistance from Mr. Earle T. Binckley, Fifth Phase Test Unit.

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ABSTRACT

Flight tests were conducted on T-29A Aircraft at Wright-Patterson Air Force Base, to evaluate the aircraft for all-weather flying capabilities. All flying was accomplished by personnel of the All Weather Section, Flight Test Division.

Data were gathered on operation of the aircraft from take-off to landing under simulated and actual instrument conditions to determine the feasibility of instrument flight and to recommend instrument flight techniques to be incorporated in the Handbook of Flight Operating Instructions.

The aircraft was found to be satisfactory for all-weather operations except for restrictions imposed by freezing precipitation during take-off or severe icing at cruising altitude.

The security classification of the title of this report is UNCLASSIFIED.

PUBLICATION REVIEW

Manuscript Copy of this report has been reviewed and found satisfactory for publication.

FOR THE COMMANDING GENERAL:



E. M. GAVIN, Colonel, USAF
Chief, Flight Test Division

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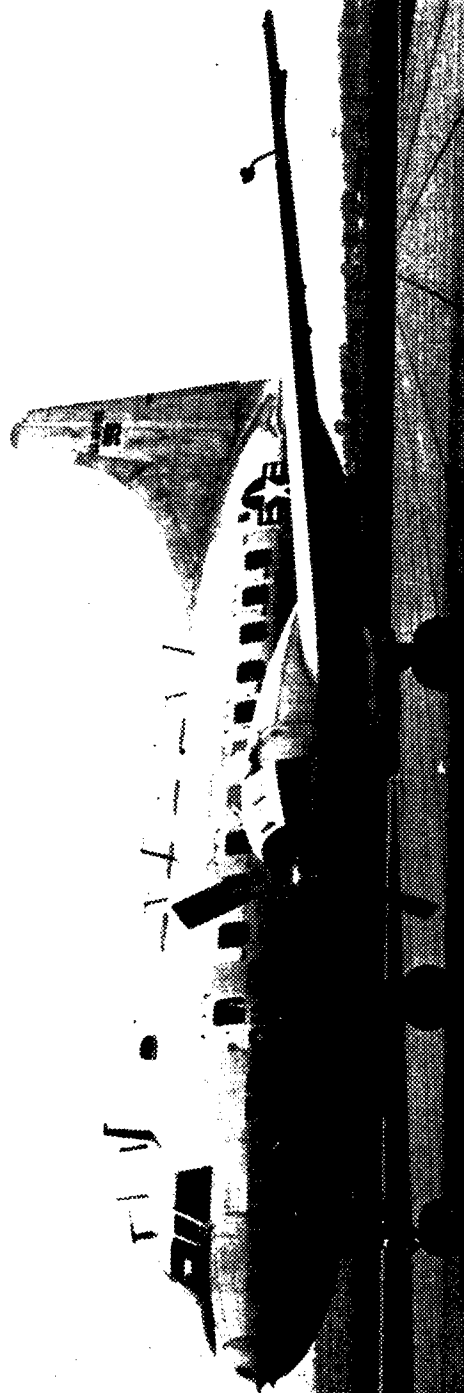


Side View of T-29A Aircraft

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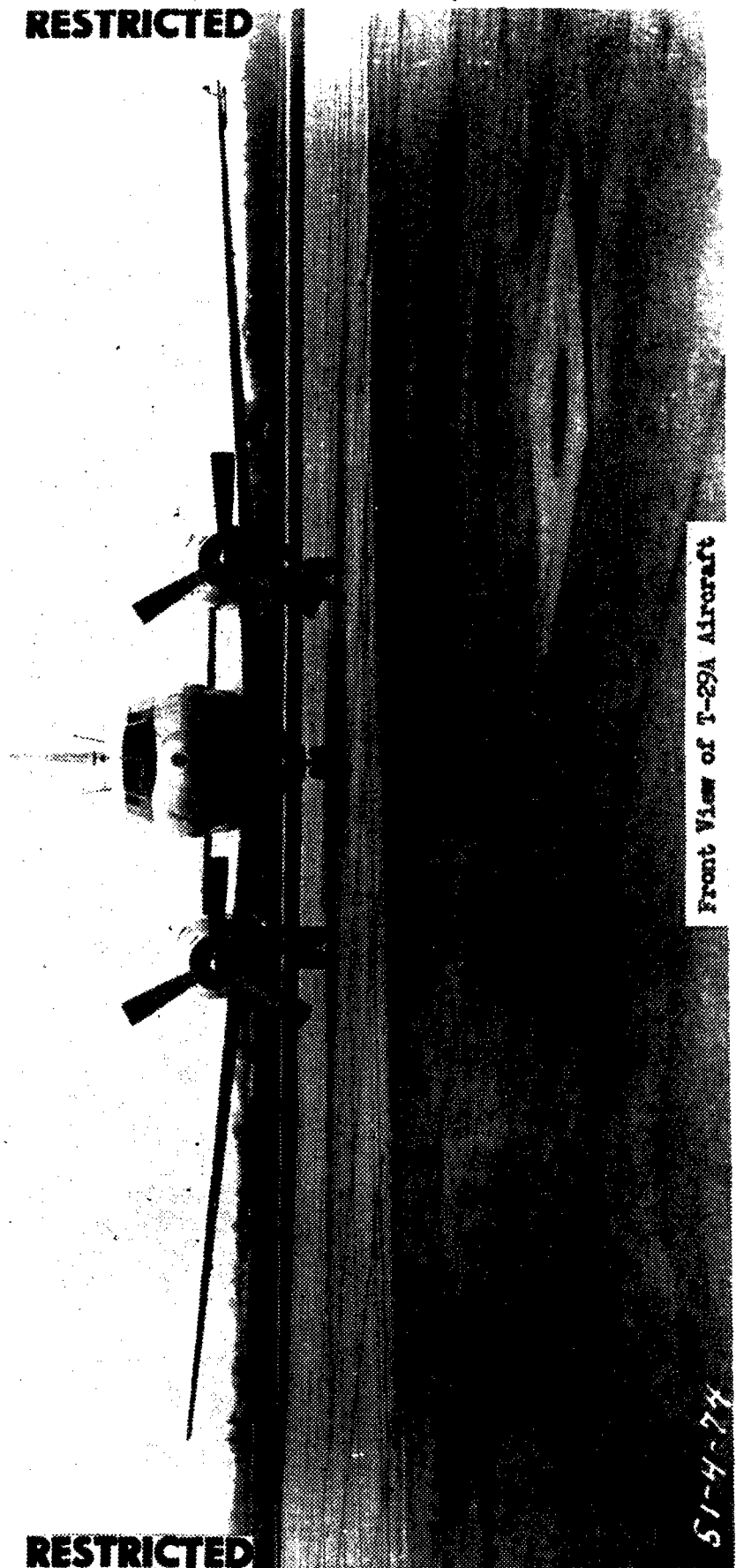


Three-quarter View of T-29A Aircraft

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Front View of F-29A Aircraft

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I - INTRODUCTION

Fifth Phase testing is conducted to evaluate aircraft suitability for all-weather operation and to develop pilot techniques for operating the aircraft under all-weather conditions from instrument take-off to landing.

In this report the person occupying the left seat in the cockpit will be referred to as the pilot and the person occupying the right seat will be referred to as the copilot. The successful operation of the aircraft depends upon the complete coordination of these two crew members.

Flight tests were conducted on a T-29A production aircraft, USAF No. 48-1911, from 29 August 1951 to 12 March 1952, at Wright-Patterson Air Force Base, Dayton, Ohio.

Test flights were conducted over the permissible center of gravity range. Gross weights varied from 32,000 lbs to a maximum of 40,500 lbs. The power settings and speeds given in this report for instrument approaches are based on an average gross weight of 35,000 lbs and a mid-position C.G. of 24% M.A.C.

The Phase V project flight time consisted of 60 flights totaling 142:40 hours. The breakdown of flight time during the tests is as follows:

DAY			NIGHT	
<u>VFR</u>	<u>IFR</u>	<u>HOOD</u>	<u>VFR</u>	<u>IFR</u>
56:40	17:10	57:55	6:35	4:20

II - DESCRIPTION

The Consolidated T-29A is a medium range, high-speed monoplane designed to serve as a radar navigational trainer. It is powered by two water-injection type Pratt and Whitney R-2800-97 reciprocating engines, driving hydromatic propellers in normal and reverse pitch. The propellers are equipped for manual or automatic feathering.

The normal operational crew consists of pilot, copilot, crew chief and instructor/radio operator. In addition to the seating arrangements for the crew, there are fourteen navigational and radar training positions installed, each equipped with a desk and necessary radar or navigational instruments.

III - EVALUATION

A. Cockpit Layout

1. General Layout

The cockpit is roomy, the general layout is satisfactory, and there is ample seat and rudder pedal adjustment to ensure comfortable seating for pilots of average size. However, pilots of small stature encounter difficulty in obtaining full rudder travel. All controls and switches are visible and within reach of the crew member concerned.

2. Visibility

Visibility from the cockpit is very good. In the take-off position, the ground can be seen over the nose to within 35 feet of the aircraft. Nesa glass is used in the windshield and a wiper is also installed. This combination permits good visibility even in conditions of light to medium precipitation and icing. Although the direct view windows, located on each side of the windshield, are designed for use in the event the Nesa glass cannot remove the windshield ice, they are not satisfactory. The windows are hinged to swing less than 90° toward the center of the cockpit and the pilot must lean far to the side to observe the runway. In this position, he cannot monitor his own air-speed indicator, but must use the copilot's to maintain safe approach speed. Another disadvantage is that the air stream is directed against the face and eyes of the pilot to such an extent that goggles should be used. (See Fig 1).

3. Instrumentation

a. Arrangement

The arrangement of the instrument flight group conforms with USAF standards. All flight instruments can be seen except the Turn and Bank Indicator, which is screened by the control column when the seat is lowered.

b. Lighting

The red and white instrument panel lighting located under the glare shield is satisfactory and no bad reflections occur from the windshield or cockpit windows. The white floodlights are sufficiently brilliant to prevent the pilot from being blinded by lightning flashes while flying in the vicinity of thunderstorms at night.

c. Operation

In general, the instruments installed in the T-29A can be used to perform instrument flight, but several of them add considerably to the pilot's workload by their unsatisfactory operation or presentation. Principal among these instruments are:

c. Operation (contd)

- (1) The A-2 Vertical Gyro - This type of attitude indicator is much too sensitive for use in this aircraft as the horizon bar moves too far for any given angular change in pitch. The instrument is also subject to errors which appear to the pilot as pitch and roll errors, both during turns and after completing them. These errors increase with bank angle and air speed and are greatest in a 180° turn. The time required for this instrument to erect (up to 13 minutes) is excessive.
- (2) C-5A Directional Gyro - This heading indicator, when not completely or correctly uncaged, has an abnormal rate of precession which makes it unreliable. The circle at the end of the needle interferes with the reading of the instrument. The instrument requires too much attention to make it satisfactory for instrument flight. This is particularly noticeable during a ground controlled approach. Inasmuch as the instrument is calibrated in increments of 5°, it is necessary to interpolate to make small heading corrections.
- (3) The V-3 Gyrosyn Compass, used as a heading indicator on the copilot's panel, although much better than the C-5A, is not entirely satisfactory for accurate instrument flight. The presentation is so small that minor deviations from heading are difficult to detect, particularly at night.

d. Radio Equipment

The cross pointer indicator (I-101-C), the marker beacon, and the command radio are connected through a switch at the radio operator's position, (See Fig 2) and by inadvertently operating this switch, the radio operator could turn off the pilot's equipment enumerated above. The operation of the above equipment is further jeopardized because the power source is derived from the secondary bus bar. In the event of engine failure, the overload switch cuts this equipment out of the circuit and it is necessary to override the overload switch. Since there were no warning flags on the cross pointer meter of the test aircraft, the pilot had no indication that the system had failed. On one approach it appeared that the aircraft was on the glide path and only because the pilot was monitoring the ADF did he know that the system was inoperative.

The sensing antenna for the No. 1 Radio Compass, located on the under side of the fuselage and routed around the radome, failed several times during the test flights. One break occurred at the bottom of the mast and the other breaks occurred at the junction of the insulator and the antenna. (See Fig 3).

d. Radio Equipment (contd)

The command radio control box which is normally used by the pilot for range approaches operates satisfactorily, but it is inconveniently located on the far side of the radio panel. In this location the volume control is not readily accessible to the pilot. (See Fig 4).

On several occasions, while being tracked by radar, the aircraft disappeared from the scope. Qualified radar controllers indicated that the return from this aircraft is not adequate and that some type of radar reinforcement is necessary to permit positive radar traffic control.

This aircraft is equipped with only one ADF radio set (ARN-6) located in the pilot's compartment. While navigating on airways or while holding in a "stack" between a range station and a "homer", the disadvantage of having only one ADF is reflected in an increased pilot workload. With a single ADF and under the above conditions (holding) it is necessary to constantly tune in each station when proceeding towards it. This is an added workload and is a potential flight hazard in the event the set is tuned to the wrong station. Under the same conditions, using two ADF's, the whole procedure is simplified by tuning in both stations, one on each radio compass, and homing back and forth until cleared for approach.

Precipitation and "crash" static materially affect signal reception on the ARN-6. In severe cases, the ADF is useless until the static diminishes. When static free omni equipment is available for installation, a dual installation will be necessary to provide the desired operation indicated above.

4. Lighting

a. Interior

The lighting of the instrument panel discussed under Instrumentation is considered satisfactory; however, the following deficiencies exist in the system:

- (1) The circuit breaker panel behind the copilot is unlighted and, when flying at night, it is necessary to use either the dome light or a flashlight to check the circuit breakers. (See Fig 5).
- (2) The trim tab indicators are unlighted.
- (3) The white flood light, installed on the pilot's dome light panel and actuated by the switch on the pilot's and copilot's control wheel, satisfactorily floods the cockpit with light. However, by inadvertently touching the switch on the wheel, as has often been done, both the pilot and copilot are distracted. There is seldom, if any, occasion to momentarily use this light.

a. Interior (contd)

- (4) The two map lights, installed in the pilot's dome light panel, are useful and satisfactory. However, when used as map lights, it is awkward to use the switches which are adjacent to the lights on the dome light panel.

b. Exterior

- (1) The exterior lighting is satisfactory.
- (2) The taxi light, mounted on the nose-wheel strut, is excellent for use during ground operation. It turns with the nose wheel and enables the pilot to locate the taxiways after landing. It also saves an immense drain on the battery which normally results when using the landing lights for taxiing.
- (3) The wing scanning lights, located outboard of each engine nacelle, are excellent for determining wing icing during flight at night. Their useful function could be enhanced by placing them in the upper portion of the fuselage. In this position it would enable the pilot to scan the engine nacelles for oil leaks as well as ice build-up on the wings. (See Fig 6).

5. Miscellaneous Equipment

The APS-23 Radar navigational equipment works satisfactorily and is of great assistance whenever trouble is experienced with the ADF equipment. It may also be used to locate "soft spots" in thunderstorm activity.

The cockpit heating on the test aircraft was unsatisfactory. The automatic temperature control did not give positive control of the heat in the cabin nor the cockpit and, during the early portion of the flight tests, the automatic feature of the system failed. For the remainder of the tests it was wired in the manual position.

There is no external connection to the heating ducts to provide ground heating of the cabin.

B. Handling Characteristics

1. Ground Handling

Ground handling characteristics are excellent. Directional control is accomplished by nose wheel steering and this, combined with the very efficient braking system and the reversible propellers, makes the aircraft extremely maneuverable on the ground.

2. Flight Handling

a. Stability

The aircraft has satisfactory stability characteristics during instrument flight.

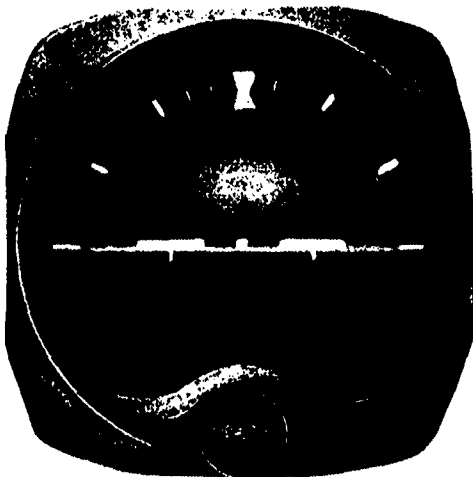
b. Control Effectiveness

Elevator control is not sufficient with the center of gravity of the aircraft near the forward limit. Rudder effectiveness is satisfactory throughout the speed range. At high speeds excessive forces are encountered in movement of the ailerons, but at approach speeds these forces are satisfactory.

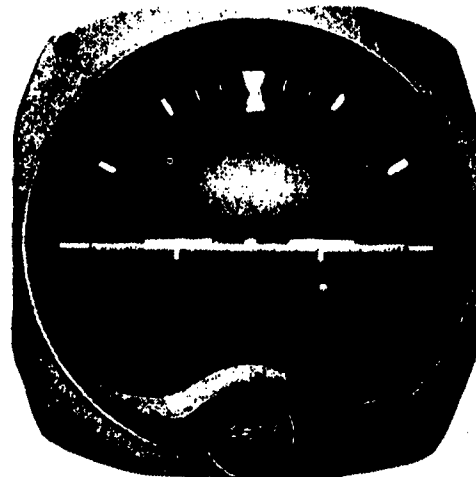
c. Take-off

Instrument take-offs are easily accomplished for all allowable weight loads except when the weight distribution brings the center of gravity near the forward limits. In this condition, excessive stick force is required for take-off.

During run-up prior to take-off, it is advisable to park adjacent and parallel to the take-off runway to minimize turn error in the A-2 Vertical Gyro.

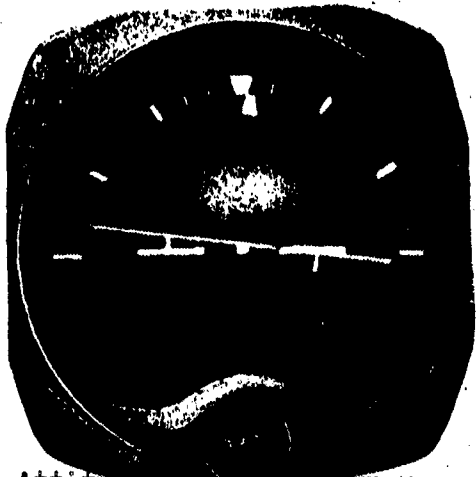


Attitude Gyro in run-up position.



Attitude Gyro after run-up and in take-off position following two 90° turns which cancel out the precession.

c. Take-off (contd)



Attitude gyro after run-up and in take-off position following a 90° turn on to runway.

As noted in the illustration to the left, the horizon bar is displaced in both pitch and roll. The pitch error can be adjusted by moving the reference plane to coincide with the bar, but there is no way of adjusting the roll error. Most pilots are capable of interpreting this error, although it does impose an additional workload at a critical time and thereby jeopardizes the instrument take-off. If a vertical gyro (J-8) incorporating a manual erection knob is installed, the pilot can center the horizon bar and eliminate the turn error.

Directional control is easily maintained by use of the steerable nose wheel until the rudder becomes effective. Severe vibration of the instrument panel at speeds between 40 and 60 knots, however, makes it difficult to read the heading indicator, and should a swing develop, it is unlikely that it would be noticed immediately by reference to the instruments alone. (See Fig 7).

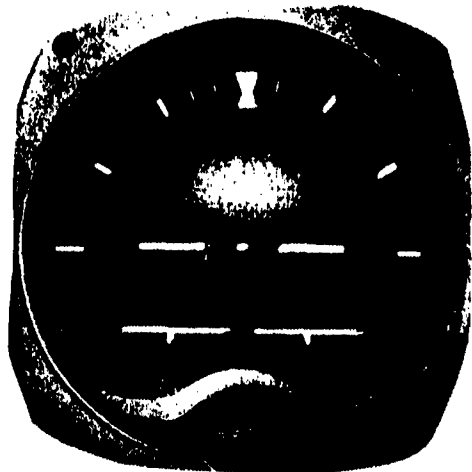
Owing to numerous failures of the water injection regulators, the majority of the take-offs were limited to 53.5" Hg, dry. When power was advanced beyond this with water injection "on", the engines would cut out and backfire. By reducing the power and cutting off the water injection, the engines would function properly.

d. Initial and Continuous Climb

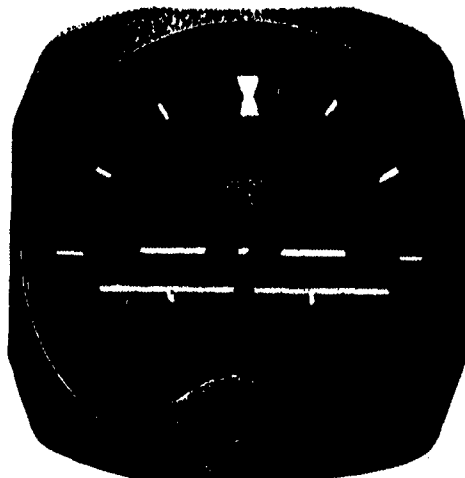
There is no difficulty in establishing and maintaining a climb and relatively little trim change is encountered when landing gear and flaps are retracted. As the gear and flaps retract and the aircraft accelerates to climbing speed, approximately 1° nose down trim is required to relieve stick force. Although the trim changes required during flap operation are not excessive, it would reduce the pilot workload if the trim requirements were automatically accommodated when the flaps were actuated. Flap retraction during an instrument take-off would not then necessitate the manual operation of the trim tab to relieve the stick force. Likewise, when extending the flaps during instrument approaches, there would be no additional workload on the pilot.

d. Initial and Continuous Climb (contd)

The attitude of the aircraft at recommended VFR climbing speed (122K) is $22\frac{1}{2}^{\circ}$ nose up; however, the presentation of the A-2 Vertical Gyro at this speed makes it difficult to maintain this attitude in instrument flight. For ease of operation, instrument climbs were made at 140K which gives a more flyable presentation on the attitude indicator, as noted in the following illustrations.



Attitude Gyro at climbing speed - 122K



Attitude Gyro at climbing speed - 140K

Turns up to a maximum of 30° angle of bank can be made safely at an indicated air speed of 150 knots or below; however, during the tests it was determined that 20° was the optimum angle of bank. There was less precession in the attitude indicator and altitude and air speed were more easily maintained. A 20° angle of bank at 130 knots results in approximately a 3° per second rate of turn. To achieve precision instrument flying with the present instrumentation, the angle of bank in a turn should be limited to a 3° per second rate of turn.

e. Cruise

The aircraft is stable during normal cruise conditions, and there is no difficulty in maintaining accurate heading and altitude.

f. Instrument Approach

The air speed flown during instrument approaches (110-120K) requires the aircraft to operate near the bottom of the power curve. A slight decrease in power and/or air speed will set up a cycle of nose-up trim requirements and reduced air speed owing to the nose high attitude and increased drag. This is especially noticeable at or below 110 knots in level flight. Also, at

f. Instrument Approach (contd)

these speeds the aircraft has a "mushy" feeling and the control column has a tendency to oscillate. If the air speed is maintained at approximately 115 knots or greater, there is adequate positive control to execute GCA or ILAS (either manual or automatic) to the minimum approach altitude; however, the presentation of the attitude and heading indicators makes precision instrument flying difficult.

6. Night Flying

Except as previously noted under Lighting, night operation of this aircraft is satisfactory and poses no particular problems. Use of the reverse pitch during a landing roll imposes a severe load on the electrical system with a consequent reduction in the power available to other electrical equipment being used.

C. Turbulence

The aircraft can be flown through heavy turbulence without difficulty provided the penetration is made at the recommended air speeds. The most comfortable speed while still retaining adequate control is 152 knots.

D. Icing

1. Wing and Tail Anti-Icing

Heated ram air for wing leading edge anti-icing is taken from muffs surrounding the outboard augments tubes in each nacelle. Muffs on the inboard augments tubes supply heated air for empennage anti-icing. Control of heated air temperature is obtained by positioning movable vanes located in the aft ends of the augments tubes. This system operated satisfactorily during all the icing tests flown, although on some flights, losses of air speed and run-back were noted. A discrepancy of this system is that no provision is made for de-icing the aircraft during ground operation. On several occasions it was necessary to abort take-off because of freezing rain and/or frost adhering to the wings. The wings do not receive sufficient heat during the ground roll to remove any ice accumulation prior to take-off. This is the greatest single deterrent to the all-weather capabilities of the aircraft.

2. Windshield Anti-Icing

Windshield and direct view panel anti-icing are accomplished by means of electrically heated Nesa glass. A-C power for glass heating is furnished from the No. 1 Alternator Bus. For operation of this system it is necessary to position the control at "start" and permit the glass to warm up for approximately 10 minutes before full heat is obtained. This system operated satisfactorily throughout the tests, and was adequate for preventing icing of the windshield during the icing conditions encountered. However, the side windows, which are unheated, accumulated ice and it was impossible to scan the engines and wings. Nesa glass in the side windows would eliminate this condition.

3. Propeller De-Icing

The propellers are electrically anti-iced with the heating elements receiving current at intervals by means of a timer so that each is heated in turn to loosen the ice and free it for removal by centrifugal force. A-C current for this operation is also supplied from the No. 1 Alternator Bus. This system functioned adequately in flight but there are no means of checking the operation prior to take-off. There should be available to the pilot either ammeters and/or lights to indicate proper functioning of the equipment prior to take-off.

4. Anti-Icing Controls

All the heating, anti-icing, and defrosting controls, with the exception of the augments, are located on the copilot's console. These controls are well grouped and easily accessible. The temperature gauges for the wing and tail anti-icing systems are located on the pilot's instrument panel.

E. Automatic Pilot Operation

Throughout the test program, the automatic pilot functioned satisfactorily under varied weather conditions. Numerous single engine automatic ILAS approaches were made. At no time did the asymmetrical power from the operating engine overpower the automatic pilot.

F. Unsatisfactory Reports

The following unsatisfactory reports were submitted:

1. Installation of the ADF radio compass antenna. (Broken)
2. Installation of pilot's dome light switch.
3. Installation of pilot's instrument panel. (Excessive vibration)
4. Pilot's attitude gyro instrument.
5. Copilot's attitude gyro.
6. Water injection regulators. (Malfunctioning)
7. Inadequacy of direct view panels.
8. Presentation of heading indicator. (C-5A)
9. Ground check of prop anti-icing system.
10. Ground operation of wing anti-icing system.
11. Use of secondary bus to supply power for ILAS, low frequency radio, and marker beacon.

F. Unsatisfactory Reports (contd)

12. Illumination of trim tab indicators.
13. Disconnect dome light control switch on control column. (See 4a(3)).
14. Illumination of copilot's circuit breaker panel.

IV - CONCLUSIONS

Although the T-29A appears to be well suited to perform its design mission, its all-weather capabilities are limited because of the absence of the following equipment:

1. An attitude indicator with proper presentation and sensitivity.
2. A heading indicator with an acceptable presentation.
3. An instrument panel that is not susceptible to severe vibrations during instrument take-off.
4. An adequate system for de-icing the wings during ground operation.

V - RECOMMENDATIONS

The all-weather capabilities of the T-29A could be improved by accomplishing the following:

1. Replace the A-2 Attitude Indicator with a suitable 5" attitude indicator.
2. Replace the C-5A Heading Indicator with a remote indicating V-7 (or comparable type) indicator and install a C-5B or improved directional gyro heading indicator on the copilot's panel.
3. Modify the instrument panel mounting to eliminate the vibration encountered during take-off.
4. Relocate the radio command control box to be more accessible to the pilot.
5. Illuminate the circuit-breaker panel behind the copilot.
6. Disconnect the dome light from the control column switch and place the switch adjacent to the light.
7. Connect the switch in the control column to actuate the map lights.

V - RECOMMENDATIONS (contd)

8. Redesign the direct view panels for better vision and divert the air stream around the opening to permit easier use of the panel.

9. Eliminate the switch on the radio operator's panel that controls the command radio, cross pointer meter, and the marker beacon.

10. Redesign the No. 1 radio compass sensing antenna to prevent its breaking in flight.

11. Illuminate the trim tabs indirectly.

12. Provide a means of de-icing the wings during ground operation.

13. Provide an infallible water injection regulator.

14. Provide a means of heating the cabin through the normal heating and ventilating ducts while aircraft is on the ground.

15. Incorporate an automatic trim tab adjustment to function in conjunction with flap operation.

16. Install a production type instrument hood.

17. Install two radio compasses in the pilot's compartment.

18. Install a radar beacon to enable infallible identification and tracking under any weather conditions.

19. Relocate the scanning lights from their present location to a position near the top of the fuselage.

20. Improve the cockpit and cabin heating system to provide positive thermostatic control.

21. Provide a means of ground checking the operation of the propeller anti-icing system.

22. Provide Nesa glass for the side windows in the cockpit.

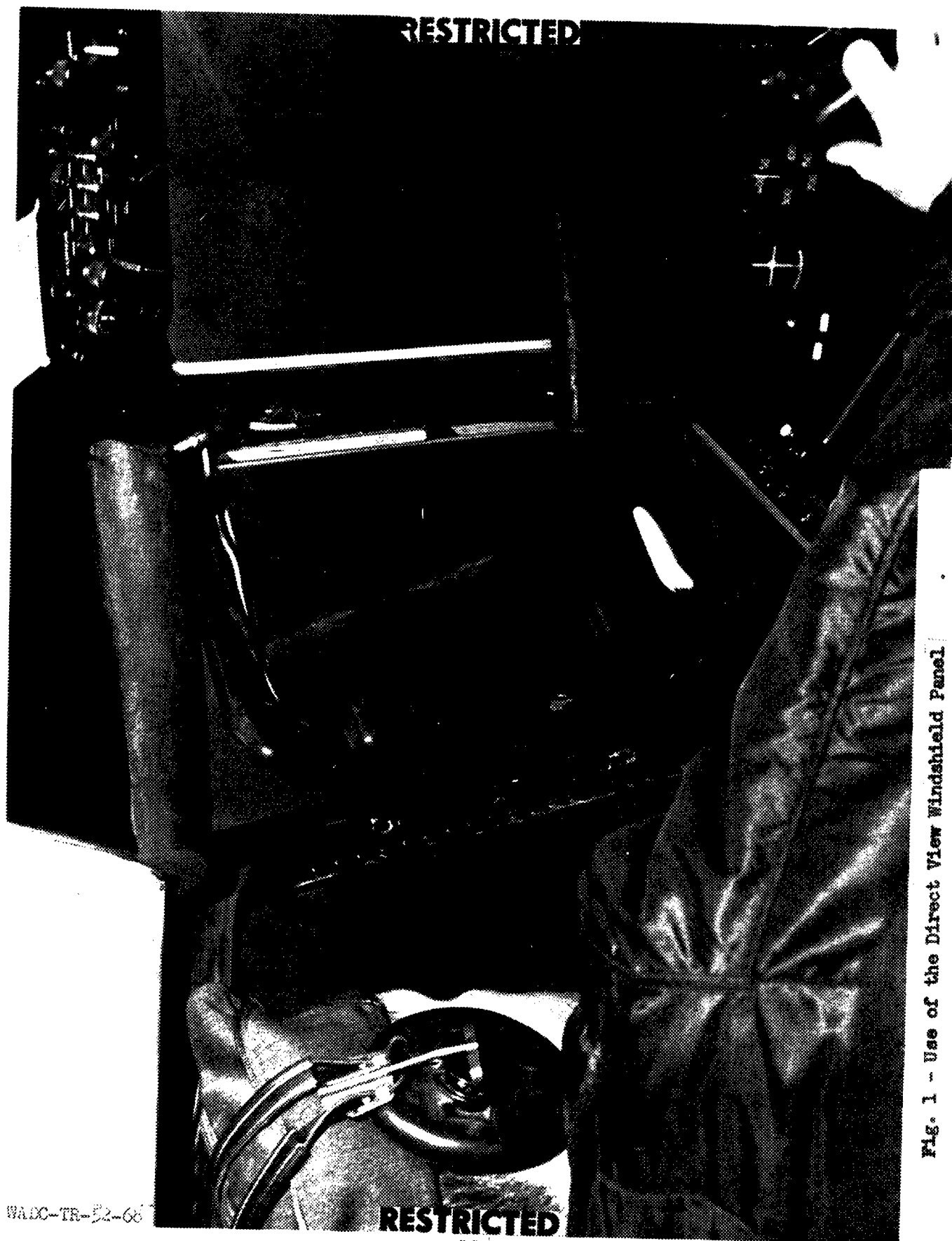


Fig. 1 - Use of the Direct View Windshield Panel

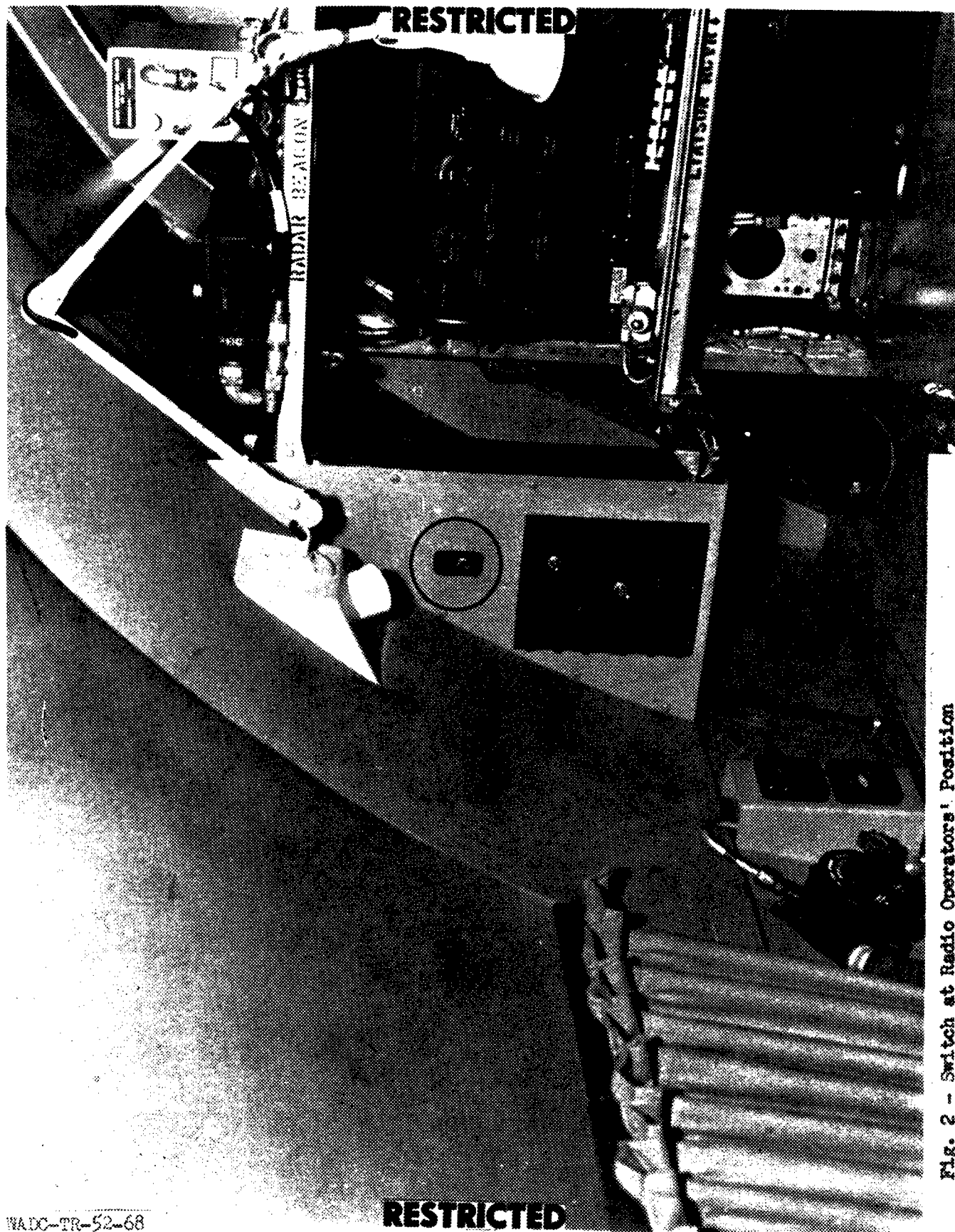


Fig. 2 - Switch at Radio Operators' Position

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Fig. 3 - Sending Antenna Installation for Radio Compass

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Fig. 4 - Location of Command Radio with Respect to the Pilot

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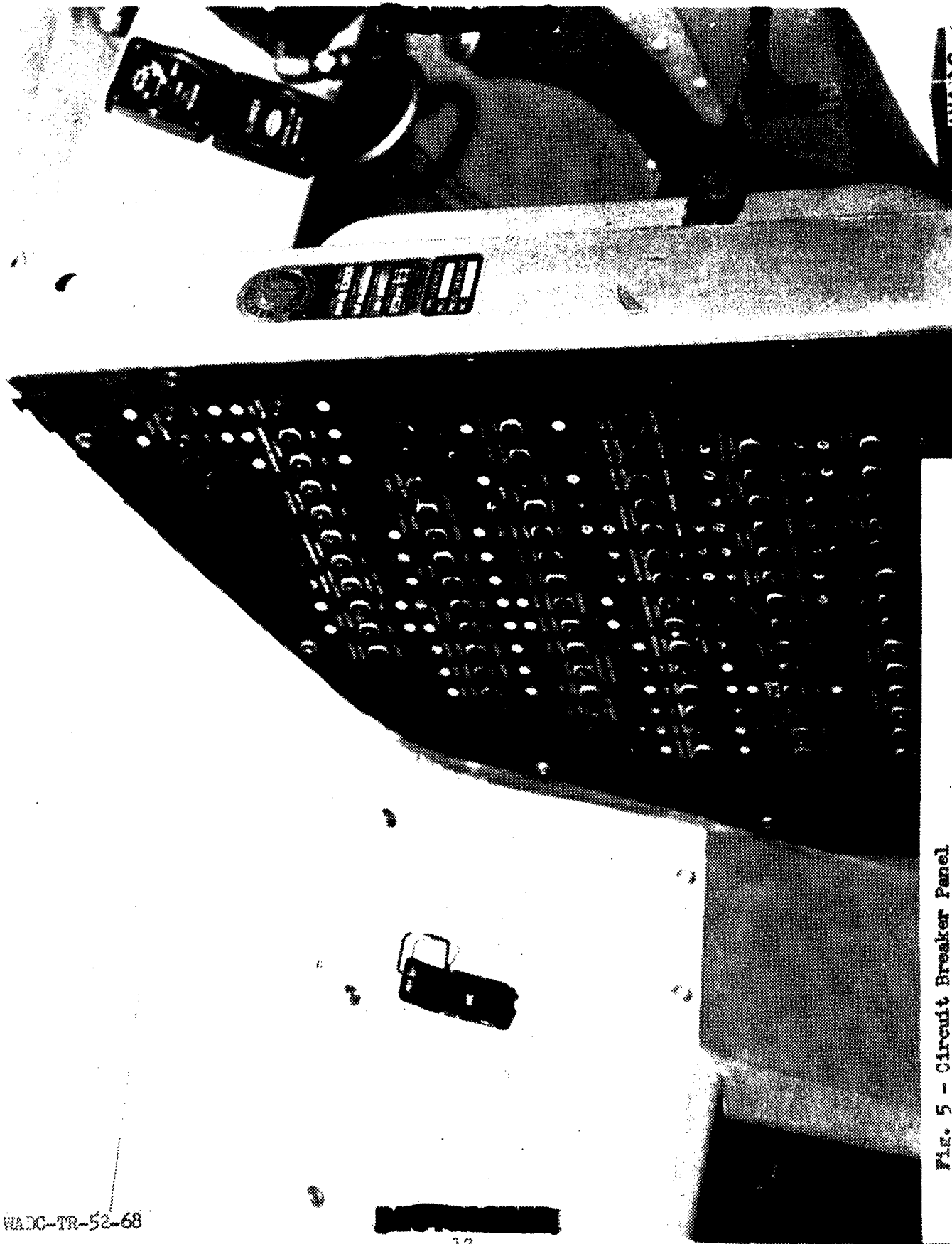


Fig. 5 - Circuit Breaker Panel

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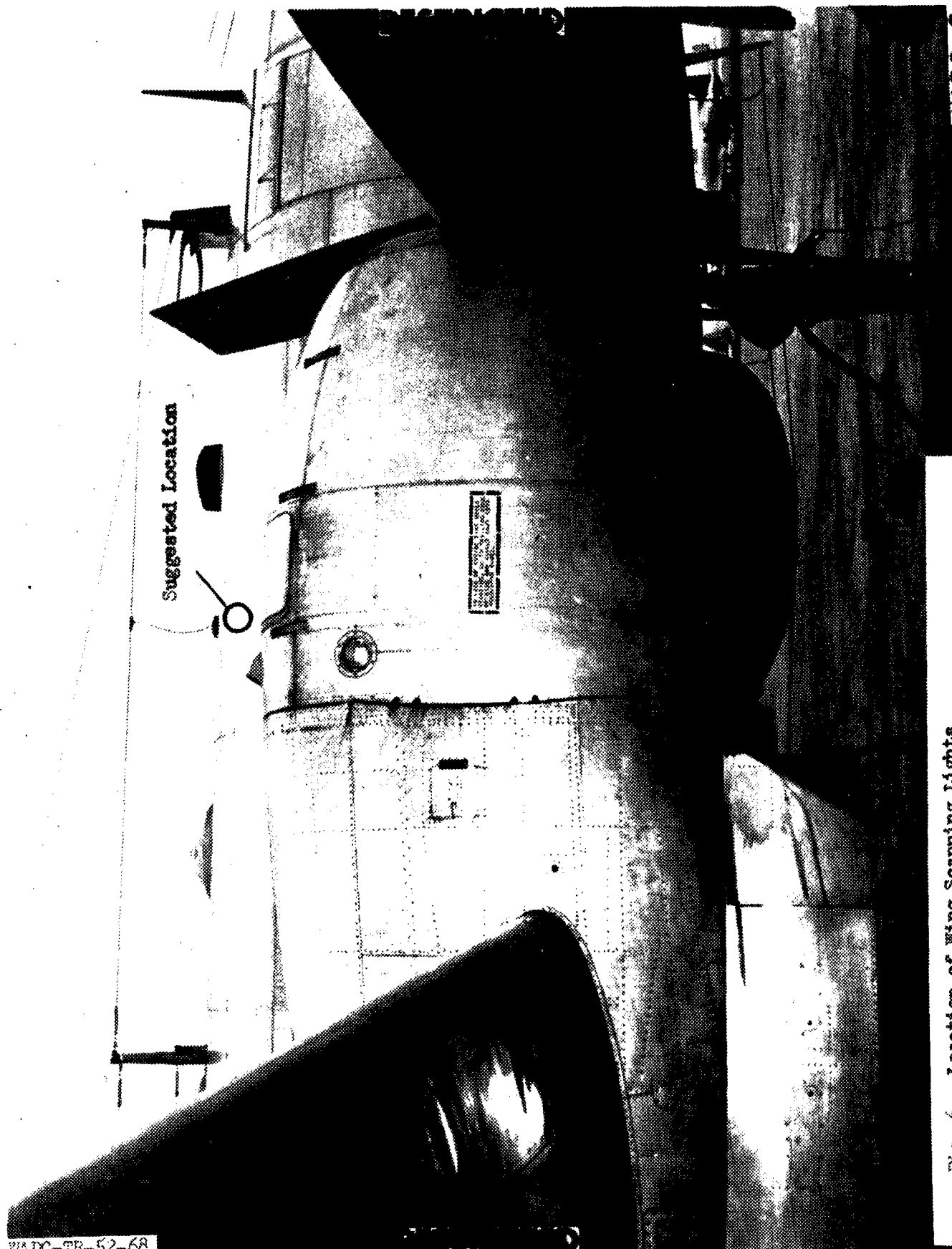


Fig. 6 - Location of Wing Scanning Lights

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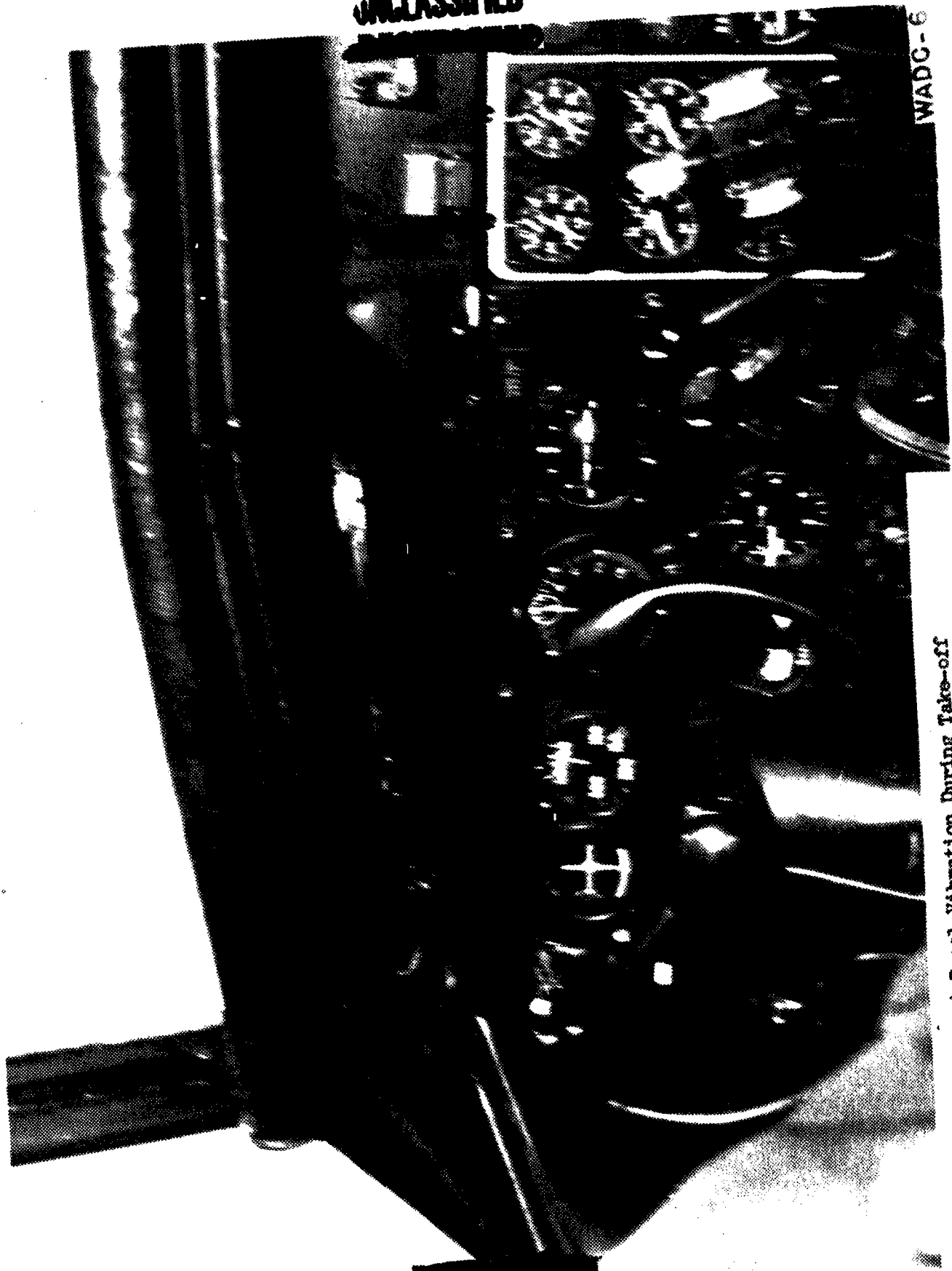


Fig. 7 - Instrument Panel Vibration During Take-off

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